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TRANSMISSION DEVICE
[HENSOKU SOCHI]

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(54) [Title of the Invention] /1*

Transmission Device

[Claims] /2

[Claim 1] A transmission device characterized by respectively arranging a speed-changing shaft using a hydraulic clutch mechanism on the transmission upstream and downstream side of a speed-changing shaft using a synchromesh mechanism in a construction in which each speed-changing shaft is shifted with an actuator by electromagnetic control.

[Claim 2] A transmission device characterized by providing a first speed-changing shaft on the line of extension from a drive shaft, providing the first speed-changing shaft thereof with two hydraulic clutches which turn on/off the rotational power from the aforesaid drive shaft to the concerned first speed-changing shaft, and at the same time, providing a second speed-changing shaft in parallel to the aforesaid first speed-changing shaft, providing the second speed-changing shaft thereof with two hydraulic clutches which turn on/off the rotational power from the aforesaid drive shaft to the concerned second speed-changing shaft, and having a speed-changing shaft in which the hydraulic clutch on the first speed-changing shaft side and the hydraulic clutch on the second speed-changing shaft are arranged in the proximity of the direction crossing the axial direction.

*Number in the margin indicates pagination in the foreign text.

[Detailed Specifications]

[0001] [Technical Field of the Invention]

The present invention relates to a transmission device for traveling vehicles, such as tractors.

[0002] A transmission device for a tractor comprises forward/reverse speed-changing shaft, a main speed-changing shaft, and auxiliary speed-changing shaft(s), and forwarding and reversing are switched by the forward/reverse speed-changing shaft, and at the same time, a number of (e.g., 16) speed-changing positions are set by combining main shifting in the main speed-changing shaft with auxiliary shifting in the auxiliary speed-changing shaft. In a conventional tractor, each of these speed-changing shafts have been composed of a synchromesh mechanism or of a hydraulic clutch mechanism.

[0003] The construction using a synchromesh mechanism has an advantage because the structure is simpler and cheaper than the construction using a hydraulic clutch mechanism, and on the other hand, it has a disadvantage because a clutch for cutting off power on the transmission upstream side or downstream side of the speed-changing shaft is required in order to synchronize rotation on the transmitting side and the transmitted side, and moreover, the number of operation processes increase during shifting because a clutch is provided, so a quick shifting cannot be performed.

[0004] By contrast, the construction using a hydraulic clutch mechanism can instantly turn on/off transmission between the transmitting side and the transmitted side; hence, shifting can be performed quickly and smoothly without providing a separate clutch. However, this construction using

a hydraulic clutch mechanism must be provided with an oil passage inside the drive shaft to send hydraulic fluid; hence, there are problems because the structure is complex and the longitudinal length of the entire transmission device increases when the respective speed-changing shafts are arranged longitudinally. Furthermore, assuming all speed-changing shafts are hydraulic clutch mechanisms, there is also a major problem because the cost increases.

[0005] Therefore, constructions have been proposed (Tokko No. 61-58691 and Jikko No. 6-2038) in which a clutch for shifting is not separately provided by combining the speed-changing shaft using a synchromesh mechanism and the speed-changing shaft using a hydraulic clutch mechanism and performing shifting in the speed-changing shaft using a synchromesh mechanism when the speed-changing shaft using a hydraulic clutch mechanism is turned off.

[0006] [Problems to be Solved by the Invention]

However, a plurality of speed-changing shafts had to be switched and operated while changing speed-changing positions, so if it was a construction in which the speed-changing shaft using a synchromesh mechanism and the speed-changing shaft using a hydraulic clutch mechanism were combined as described above, shifting was not performed smoothly if the timing of the switching operation thereof was off, so a shock occurred.

[0007] Moreover, since the transmission structure disclosed in Tokko No. 61-58691 had multiplate hydraulic clutches **29**, **30**, **31** and **32** provided on clutch support shafts **17** and **18** arranged on the outside of a drive shaft **16** and a driven shaft **9**, there was a problem because this structure

was unwieldy in the longitudinal direction and the directly forward direction.

[0008] In view of the above-mentioned circumstances, the issue of the present invention is to provide a relatively low-cost and compact transmission device so as to realize no clutch to enable an agile shifting operation, which is suited to a small- or medium-sized tractor.

[0009] [Means for Solving the Problems]

In order to solve the above-mentioned issue, the present invention was constituted as follows. That is, the transmission device pertaining to the present invention characterized by respectively arranging a speed-changing shaft using a hydraulic clutch mechanism on the transmission upstream and downstream side of a speed-changing shaft using a synchromesh mechanism in a construction in which each speed-changing shaft is shifted with an actuator by electromagnetic control, and a construction is obtained in which a clutch for shifting is not separately provided by performing shifting in the aforesaid speed-changing shaft using a synchromesh mechanism when the aforesaid speed-changing shaft using a hydraulic clutch mechanism is turned off.

[0010] Moreover, the transmission device pertaining to the present invention is characterized by providing a first speed-changing shaft on the line of extension from a drive shaft, providing the first speed-changing shaft thereof with two hydraulic clutches which turn on/off the rotational power from the aforesaid drive shaft to the concerned first speed-changing shaft, and at the same time, providing a second speed-changing shaft in parallel to the aforesaid first speed-changing shaft, providing the second

speed-changing shaft thereof with two hydraulic clutches which turn on/off the rotational power from the aforesaid drive shaft to the concerned second speed-changing shaft, and having a speed-changing shaft in which the hydraulic clutch on the first speed-changing shaft side and the hydraulic clutch on the second speed-changing shaft are arranged in the proximity of the direction crossing the axial direction.

[0011] [Embodiments of the Invention]

A practical example of a tractor provided with the transmission device of the present invention will now be described.

[0012] The tractor **1** shown in Fig. 1 is a front and rear four-wheel drive vehicle which is equipped with front wheels **2** and **2** and rear wheels **3** and **3** in the corners of a frame. A front wheel axle case **5** which supports the axle of the front wheels **2** and **2** is installed on the underside of the front frame **7**, and the rear wheel axle cases **6** and **6** which support the rear wheels **3** and **3** are installed on the posterior flank of an automatic transmission case **8**. The front rear axle case **5** is rotatably supported by the front frame **7** in the center in the horizontal direction to freely shake horizontally about a fixed shaft center facing the longitudinal direction, and the front wheels **2** and **2** move vertically due to the unevenness of the ground.

[0013] An engine **10** is mounted to freely detach on the center top side of the front frame **7**. **11** is a radiator; **12** is a cooling fan; and **13** is a fan belt. These parts are disposed in front of the engine **10**. **14** is a hood, which covers the engine **10** and its accessories (not shown)

at the front and rear. /3

[0014] **16** is a steering wheel. By rotating this steering wheel to the right or left, the front wheels **2** and **2** are steered and shake horizontally. Moreover, **17** is a gear change for carrying out a shifting operation. Fenders **21** and **21** are installed extending from in front of the right and left rear wheels **3** and **3** to above them, and a seat **22** is provided between these right and left fenders **21** and **21**. The driver's underfoot part on the under side of the seat **22** is substantially a flat floor **23**.

[0015] Lift arms **27** and **27**, which are turned vertically by an ascending/descending hydraulic cylinder **26**, are provided at the rear of the frame. The tips of these lift arms **27** and **27** and the middle area between the lower links **27a** and **27a** used for mounting implements are coupled by lift rods **27b** and **27b**, and upon these lift arms **27** and **27** being actuated vertically, an implement, such as a rotary tilling device, which is mounted to the rear ends of the lift rods **27b** and **27b**, ascends/descends. Moreover, one of the lift rods **27b** and **27b** (on the right side in the illustration) is a hydraulic cylinder used for horizontal tilting, and upon contacting this hydraulic cylinder, the horizontal incline of the implement can be adjusted. Moreover, a top link **27c** is installed above and in the center between the lower links **27a** and **27a** to support the implement as a three-point link mechanism composed of the lower links **27a** and **27a** and the top link **27c**.

[0016] Figure 2 is a drawing of the transmission mechanism of this tractor and Figs. 3 to 5 are cross sections representing the structures

of the principal parts thereof. An outline of the transmission mechanism will be described first.

[0017] The rotational power of the engine **10** is inputted into the automatic transmission case **8**. A main clutch **30** is provided in the entrance portion of the automatic transmission case **8** so as to turn on/off the power transmission. The power by way of this main clutch **30** is transmitted and diverted through two PTO drive power systems for extracting a traveling drive power for driving the front and rear wheels and an external motive power. The traveling drive power is transmitted to a rear wheel differential device **34** via a traveling shifting device comprising a forward/reverse speed-changing shaft **31**, a main speed-changing shaft **32**, and an auxiliary speed-changing shaft **33**, to drive the right and left rear wheels **3** and **3**. Moreover, the motive power after shifting by means of the traveling shifting device is extracted by the front panel portion of the automatic transmission case **8** via a 4WD switching device **35**, then transmitted to a front wheel differential device **36** inside the front rear axle case **5** by a front wheel transmission shaft **5a** to drive the right and left front wheels **2** and **2**. Meanwhile the PTO drive power is extracted by a PTO shaft **39** protruding from the back face of the automatic transmission case **8** to behind it via a PTO normal/reverse rotating device **37** and a PTO shifting device **38**. A transmission shaft for each implement (not shown) is transmittingly coupled with the protruding portion of the PTO shaft **39** to freely detach.

[0018] The structure of each speed-changing shaft of the traveling shifting device is described next. The forward/reverse speed-changing shaft **31** is a speed-changing shaft which selectively switches and transmits the rotation of a main clutch shaft **S1** to a forward/reverse speed-changing shaft **S3** in the forwarding/reversing direction. A gear **G1** installed at the rear end of the main clutch shaft **S1** meshes with the gear **G2** of a relay shaft **S2**, and further, the gear **G2** meshes with a forward gear **G3** which engages with the forward/reverse speed-changing shaft **S3** by a needle bearing to freely rotate. Moreover, a gear **G4** is installed separate from the aforesaid gear **G2** on the relay shaft **S2**, and through the counter gear **G5** of the counter shaft **G4**, this gear **G4** meshes with a reverse gear **G6** which engages with the forward/reverse speed-changing shaft **S3** by a needle bearing to freely rotate, whereby the forward gear **G3** and reverse gear **G6** rotate in reverse directions to each other.

[0019] The forward gear **G3** and reverse gear **G6** are transmittingly coupled to the forward/reverse speed-changing shaft **S3** by a forward clutch C_F and a backward clutch C_B both having a wet multiplate hydraulic clutch structure. That is, a driving drum **41** is assembled so as to integrally rotate with the forward/reverse speed-changing shaft **S3** by mean of a spline, and a forward clutch boss **42F** integrally formed with the aforesaid forward gear **G3** and a backward clutch boss **42B** integrally formed with the reverse gear **G6** are attached inside this driving drum on its inner periphery, and friction plates **43, ...** on the driving drum side and friction plates **44, ...** on the forward and backward clutch boss side are arranged in a

mutually parallel state. Moreover, a forward clutch on/off piston **45F** and a backward clutch on/off piston **45B** are disposed on both sides of the partitioning wall **41a** of the driving drum **41**. Part of the lubricating oil filling the automatic transmission case **8** is suctioned and pressurized by a hydraulic pump (not shown), and upon feeding it to either an oil chamber **46F** between the partitioning wall **41a** and the forward clutch on/off piston **45F** or an oil chamber **46B** between the partitioning wall **41a** and the backward clutch on/off piston **45B** through an oil passage provided inside the forward/reverse speed-changing shaft **S3**, the forward clutch on/off piston **45F** or backward clutch on/off piston **45B** is actuated. The forward clutch C_F and backward clutch C_B are controlled to be on/off by a forward/reverse switching solenoid valve **V1** (see Fig. 6).

[0020] By actuating the forward clutch on/off piston **45F** and press-contacting the friction plates **43, ...** on the driving drum **41** side and the friction plates **44, ...** on the forward clutch boss **42F** side, the forward clutch C_F is turned on and the forward/reverse speed-changing shaft **S3** is a "reverse rotating" shift which rotates in the direction opposite that of the main clutch shaft **S1**. Moreover, when the reverse clutch on/off piston **45B** is actuated and the friction plates **43** ... on the driving drum **41** and the friction plates **44, ...** on the reverse clutch boss **42B** side are press-contacted, the back-up clutch C_B is turned on and a "reverse" shifting is performed wherein the forward/reverse shift change shaft **S3** rotates in the opposite direction of the main clutch shaft **S1**. When either forward clutch C_F or C_B is brought into a released clutch

state, and is shifted into "neutral" in which the motive power to the traveling drive system is discontinued thereafter. The hydraulic /4 press-contact and separation of the portioning plates on the transmitting side and transmitted side are performed instantly; hence, shifting in the forward/reverse speed-changing shaft **31** is achieved quickly and smoothly.

[0021] Moreover, the gear **G2** of the relay shaft **S2** meshes with a normal rotating gear **G7** which engages with the outer peripheral portion of a forward/reverse speed-changing shaft **S5** and the counter gear **G5** of a counter shaft **G4** meshes with a reverse rotating gear **G8** which meshes with the outer periphery of the forward/reverse speed-changing shaft **S5** to freely rotate, and the PTO drive power is transmitted to the PTO normal/reverse rotating device **37**. This PTO normal/reverse rotating device **37** which can transmittingly couple with and is composed of a sleeve **49** capable of axially sliding on a hub **48**, which meshes with these gears **G7** and **G8** and the forward/reverse speed-changing shaft **S5** by means of a spline, to deliver the PTO drive force to the PTO normal/reverse rotating device **37**. When the normal rotating gear **G7** and the hub **48** are transmittingly coupled, the forward/reverse speed-changing shaft **S5** rotates in the normal rotating direction, and when the reverse rotating gear **G8** and hub **48** are transmittingly coupled, the front rear axle case **5** rotates in the reverse rotating direction. When the hub **48** is not transmittingly coupled with either the normal rotating gear **G7** or reverse rotating gear **G8**, the forward/reverse speed-changing shaft **S5** stops rotating.

[0022] The main speed-changing shaft **32** is a speed-changing shaft for selectively shifting gears and transmitting power in four steps between a main shifting drive shaft **S6** provided to integrally rotate with the forward/reverse speed-changing shaft **S3** and a main gear change transmitted shaft **S7** provided parallel to the main shifting drive shaft **S6**. A 1-speed drive gear **G9**, a 2-speed drive gear **G10**, a 3-speed drive gear **G11**, and a 4-speed drive gear **G12** are provided coupled respectively with the main shifting drive shaft **S6** to freely rotate, and moreover, a 1-speed transmitted gear **G13**, a 2-speed drive gear **G14**, a 3-speed transmitted gear **G15**, and a 4-speed transmitted gear **G16** are integrally installed on the main shifting transmitted shaft **S7** in a state in which they normally mesh with the aforesaid paired drive gears **G9** to **G12**. The transmission ratio of these four 4 pairs of main shifting gears increases in order of the 4-speed gear, 3-speed gear, 3-speed gear, and 1-speed gear.

[0023] The respective drive gears **G9** to **G12** are transmittingly coupled to the main shifting drive shaft **S6** using a synchromesh mechanism. That is, a hub **51** is coupled by a spline to the main shifting drive shaft **S6**, and further, a sleeve **52** is fitted by a spline to the outer peripheral portion of this hub **51**, a key **53** fits into a groove formed in this sleeve **52**, and rings **54** and **54** are provided opposite cones **55** and **55** of the 1-speed drive gears **G9** and **G10** (or **G11** and **G12**). Upon moving the sleeve **52** in either axial direction by a shifter **56** actuated by push-pull hydraulic cylinders **A** and **B** (see Fig. 6) provided outside the automatic transmission case **8**, one of the rings **54** contacts a cone **55** of the drive gear when

the key **53** is pressed, and the rotation of the ring **54** is transmitted to the cone **55** by friction, and the rotational speeds of the drive gears and the main shifting drive shaft **S6** are synchronized. By further moving of the sleeve **52**, the spline portion of the sleeve **52** meshes with the spline portion of the drive gears, and the main shifting drive shaft **S6** and the drive gears are placed in a state in which they are perfectly coupled transmittingly. The aforesaid push-pull hydraulic cylinders **A** and **B** are controlled to push/pull by main speed changing solenoid valves **V2** and **V3** (see Fig. 6).

[0024] When the main shifting drive shaft **S6** and the 1-speed drive gear **G9** are transmittingly coupled, a "1-speed" gear shift is performed. When the main shifting drive shaft **S6** and the 2-speed drive gear **G10** are transmittingly coupled, a 2-speed gear shift is performed. When the main shifting drive shaft **S6** and 3-speed drive gear **G11** are transmittingly coupled, a "3-speed" gear shift is performed. Moreover, when the main shifting drive shaft **S6** and the 4-speed drive gear **G12** are transmittingly coupled, a "4-speed" gear shift is performed. In order to smoothly synchronize the rotation of the rotation gears **G9**, **G10**, **G11** and **G12** on the hub **51** side, it is necessary to block power transmission from the power transmission upstream side or downstream side; hence, the gear shift is performed by the forward/reverse speed-changing shaft **31** or auxiliary speed-changing shaft **33** in "neutral."

[0025] The auxiliary speed-changing shaft **33** s a speed-changing shaft for selectively changing gears to rotate the main shifting transmitted

shaft **S7** in four steps and transmits it to a first auxiliary speed-changing shaft **S8** and second auxiliary speed-changing shaft **S9**. A gear **G17** formed in a high-gear clutch boss **62** integrated with the cylindrical part **S7a** of the main shifting transmitted shaft **S7** meshes with a gear **G18** formed in an intermediate-gear clutch boss **62M**, which meshes with the second auxiliary speed-changing shaft **S9** to freely rotate, so as to decelerate and transmit power. Moreover, one more gear **G19** formed in the high-gear clutch boss **62H** meshes with a gear **G20** provided integrally with a relay shaft **S10** so as to decelerate and transmit power, and one more gear **G21** provided integrally with the relay shaft **S10** meshes with a gear **G22** formed in a low-gear clutch boss **62L**, which meshes with the first auxiliary speed-changing shaft **S8** to freely rotate, decelerates and transmits power. Furthermore, one more gear **G23** formed in the low-gear clutch boss **62L** meshes with a gear **G24**, which is formed in an ultra low-gear clutch boss **62LL**, which meshes with the second auxiliary speed-changing shaft **S9** to freely rotate, decelerates and transmits power. Therefore, each of the clutch bosses normally rotate integrally and the rotational speed thereof increases in order of the high-gear clutch boss **62H**, intermediate-gear clutch boss **62M**, low-gear clutch boss **62L** and ultra low-gear clutch boss **62LL**.

[0026] Moreover, a gear **G25**, which fits by means of a spline with the first auxiliary speed-changing shaft **S8**, meshes with a gear **G26**, which engages with the second auxiliary speed-changing shaft **S9** by means of a spline. Furthermore, a gear **G28**, which integrates with the gear **G26**,

meshes with the gear **G28** of a 4WD shifting device transmission shaft **S11**. Moreover, a drive pinion **G29**, which transmits power to the rear wheel differential device **34**, is formed integrally with the rear end portion of the first auxiliary speed-changing shaft **S8**.

[0027] The high-gear clutch boss **62H**, low-gear clutch boss **62L** and first auxiliary speed-changing shaft **S8** are transmittingly coupled by auxiliary shifting clutches C_H and C_L, and the intermediate-gear clutch boss **62M**, ultra low-gear clutch boss **62LL** and second auxiliary speed-changing shaft **S9** are transmittingly coupled by auxiliary shifting clutches C_M and C_{LL}. These auxiliary shifting clutches C_H, C_M, C_L and C_{LL} are wet multiplate hydraulic clutch grooves similar to the aforesaid forward clutch C_F and backward clutch C_B, and are respectively controlled to be on/off by auxiliary shift changing solenoid valves **V4**, **V5**, **V6** and **V7** (see Fig. 6). Only the reference code names of the auxiliary shifting clutches have been stated; **61** is a driving drum; **63** and **64** are friction plates; **65** is a piston; and **66** is an oil compartment.

[0028] The hydraulic fluid for actuating the respective /5 auxiliary shifting clutches C_H, C_M, C_L and C_{LL} is such that part of the lubricating oil filling the automatic transmission case **8** is suctioned and pressurized by a hydraulic pump (not shown), and is sent into the oil compartments **66** ... through the oil passage provided in the first auxiliary shift change shaft **S8** or the second auxiliary speed-changing shaft **S9**. The drive pinion **G29** is formed integrally with the rear end portion of the first auxiliary speed-changing shaft **S8**, enabling taking in of the

hydraulic fluid from the rear end side of the first auxiliary speed-changing shaft **S8**, so it is necessary for the hydraulic fluid sent to the oil compartments **66** and **66** of the auxiliary shifting clutches C_H and C_L to be taken in from the front end side of the first auxiliary speed-changing shaft **S8**. Therefore, through-holes **67** ... are provided in the cylindrical part **S7a** of the main shifting transmitted shaft **S7**, annular grooves **68** ... are formed on the outer periphery of the first auxiliary speed-changing shaft **S8** opposite the positions of these through-holes **67** ..., and constructed with the annular grooves **68** ... thereof and the oil passage **69** inside the first auxiliary speed-changing shaft **S8** being linked. By providing this oil passage construction, a part for taking in the hydraulic fluid into the first auxiliary speed-changing shaft **S8** is not provided specially; hence, the construction is compact, and at the same time, the part where the hydraulic fluid is taken in is positioned longitudinally in the middle of the automatic transmission case **8**; hence, the length of the piping for linking the auxiliary shift changing solenoid valves **V4**, **V5**, **V6** and **V7** provided on the outside face of the automatic transmission case **8** and the part where the hydraulic fluid is taken in can be shortened.

[0029] When the auxiliary speed change clutch C_H is turned on, the rotation of the high-gear clutch boss **62H** is transmitted to the first auxiliary speed-changing shaft **S8**, and further, the rotation of the first auxiliary speed-changing shaft **S8** thereof is shifted into "high-speed" wherein it is transmitted to the rear wheel differential device **34** by the drive pinion **G29**, and at the same time, to the 4WD shifting device

transmission shaft **S11** through a combination of the gears **G25** and **G26** and a combination of the gears **G27** and **G28**.

[0030] When the auxiliary shifting clutch C_M is turned on, an "intermediate-speed" gear shift is performed wherein the rotation of the intermediate-gear clutch boss **62M** is transmitted to the second auxiliary speed-changing shaft **S9**, and further, rotation of the second auxiliary speed-changing shaft **S9** thereof is transmitted to the first auxiliary speed-changing shaft **S8** through a combination of the gears **G26** and **G25**, then it is transmitted to the rear wheel differential device **34** by the drive pinion **G29**, and at the same time, it is transmitted to the 4WD shifting device transmission shaft **S11** by a combination of the gears **G27** and **G28**.

[0031] If the auxiliary shifting clutch C_L is turned on, a "low-speed" gear shift is performed wherein rotation of the low-gear clutch boss **62L** is transmitted to the first auxiliary speed-changing shaft **S8**, and further, rotation of the first auxiliary speed-changing shaft **S8** thereof is transmitted to the rear wheel differential device **34** by the second auxiliary speed-changing shaft **S9**, and at the same time, it is transmitted to the 4WD shifting device transmission shaft **S11** through a combination of the gear **G25** and G26 and a combination of the gear **G27** and **G27**.

[0032] If the auxiliary shifting clutch C_{LL} is turned on, an "ultra low speed" gear shift is performed wherein the rotation of the ultra low-gear clutch boss **62LL** is transmitted to the second auxiliary speed-changing shaft **S9**, and further, rotation of the second auxiliary speed-changing shaft **S9** thereof is transmitted to the first auxiliary speed-changing

shaft **S8** by a combination of the gears **G26** and **G26** and transmitted to the rear wheel differential device **34** by the drive pinion **G29**, and at the same time, it is transmitted to the 4WD shifting device transmission shaft **S11** by a combination of the gears **G27** and **G28**.

[0033] When all of the auxiliary shifting clutches C_H C_M, C_L and C_{LL} also are in a state of release, a "neutral" gear shift is performed wherein transmission of rotation from the main speed-changing shaft **32** to the front and rear wheels is discontinued, and at the same time, the rotation is blocked from being transmitted to the main speed-changing shaft **32** due to the inertia of the front and rear wheels. Press-contact and separation of the friction plate on the transmission side and the friction plate on the transmitted side is performed instantly due to the hydraulic pressure; hence, the shifting by the auxiliary speed-changing shaft **33** is performed quickly and smoothly.

[0034] The auxiliary speed-changing shaft **33**, as such, is constructed to enable shifting in four steps, with a first auxiliary speed-changing shaft **S8** provided on the line extending from the main shifting transmitted shaft **S7**, which is the drive shaft, two auxiliary shifting clutches C_H and C_L, which turn on/off the transmission of rotation from the aforesaid main shifting transmitted shaft **S7** to the concerned first auxiliary speed-changing shaft **S8** provided on the first auxiliary speed-changing shaft **S8** thereof, and at the same time, the second auxiliary speed-changing shaft **S9** provided parallel to the aforesaid first auxiliary speed-changing shaft **S8**, and two auxiliary shifting clutches C_M and C_{LL}, which turn on/off

transmission of the rotation from the aforesaid main shifting transmitted shaft **S7** to the concerned second auxiliary speed-changing shaft **S9**, provided on the second auxiliary speed-changing shaft **S9** thereof, enabling shifting in four steps.

[0035] By constructing the auxiliary speed-changing shaft **33** as such, its dimensions in the longitudinal direction are about half those of the construction in which four auxiliary shifting clutches are provided in series. Moreover, by so constructing the auxiliary speed-changing shaft **33**, which is the speed-changing shaft positioned at the rear of the frame, a shaft provided with the auxiliary shifting clutches C_H and C_L and a shaft provided with the drive pinion **G29** may be disposed as a common shaft (first auxiliary speed-changing shaft **S8**), and as a result, the number of shafts is lower than in the conventional construction disclosed in the aforesaid Tokko No. 61-58691, the number of parts is reduced, the construction becomes simple, and at the same time, the dimension in the direction(vertical direction) perpendicular to the axial direction (longitudinal direction) is shorter. Furthermore, even by arranging the auxiliary shifting clutches C_H and C_L on the first auxiliary speed-changing shaft **S8** side and the auxiliary shifting clutches C_M and C_{LL} of the second auxiliary speed-changing shaft **S9** contiguously in the vertical direction, it is possible to further shorten the dimension of the auxiliary speed-changing shaft **33** in the vertical direction.

[0036] The 4WD switching device **34** is a device which switches between a "front and rear wheel constant speed four-wheel drive" state wherein

the average rotational speed (peripheral speed) of the front wheels **2** and **2** and rear wheels **3** and **3** is substantially constant, a "front wheel accelerating four-wheel drive" wherein the average rotational speed of the front wheels **2** and **2** is substantially twice (peripheral speed ratio) the average rotating speed of the rear wheels **3** and **3**, and a "rear two-wheel drive" state wherein only the rear wheels **3** and **3** are driven by discontinuing driving of the front wheels **2** and **2**, and a construction is obtained wherein a similar wet multiplate hydraulic clutch-type shifting mechanism is used as in the forward/reverse speed-changing shaft **31** and auxiliary speed-changing shaft **33**. Moreover, the PTO normal/reverse rotating device **37** is a device for changing the speed of the PTO drive power in four (4) steps/phases, and a construction is obtained in which a dog clutch-type shifting mechanism is used.

[0037] As described above, the traveling shifting device of this tractor comprises the forward/reverse speed-changing shaft **31**, main speed-changing shaft **32** and the auxiliary speed-changing shaft **33**, forwarding and reversing are switched between by the forward/reverse speed-changing shaft **31**, and at the same time, a total 16-step speed-changing position is selected by combining a main shifting in the main speed-changing shaft **32** and auxiliary shifting in the auxiliary speed-changing shaft **33**. Combinations of the main shifting and auxiliary shifting are as shown in Table 1. /6

[0038]

[Table 1]

Speed-changing position	Main shifting (hydraulic cylinder)	Auxiliary shifting (hydraulic clutch)
1	1-speed (pull A)	Ultra low speed (C_{LL} on)
2	2-speed (push A)	Ultra low speed (C_{LL} on)
3	3-speed (pull B)	Ultra low speed (C_{LL} on)
4	4-speed (push B)	Ultra low speed (C_{LL} on)
5	1-speed (pull A)	Low speed (C_L on)
6	2-speed (push A)	Low speed (C_L on)
7	3-speed (pull B)	Low speed (C_L on)
8	4-speed (push B)	Low speed (C_L on)
9	1-speed (pull A)	Intermediate speed (C_M on)
10	2-speed (push A)	Intermediate speed (C_M on)
11	3-speed (pull B)	Intermediate speed (C_M on)
12	4-speed (push B)	Intermediate speed (C_M on)
13	1-speed (pull A)	High speed (C_H on)
14	2-speed (push A)	High speed (C_H on)
15	3-speed (pull B)	High speed (C_H on)
16	4-speed (push B)	High speed (C_H on)

[0039] The forward/reverse speed-changing shaft **31** and auxiliary speed-changing shaft **33** are hydraulic clutch mechanisms, the main speed-changing shaft **32** is a synchromesh mechanism in a construction in which the forward/reverse speed-changing shaft **31** of the hydraulic clutch mechanism and the auxiliary speed-changing shaft **33** are respectively disposed on the transmission upstream side and downstream side of the main speed-changing shaft **32** of the synchromesh mechanism. By combining the speed-changing shaft using a hydraulic clutch mechanism and the speed-changing shaft using a synchromesh mechanism as such, while performing a shifting in the speed-changing shaft by the synchromesh mechanism (main speed-changing shaft **32**), the motive power can be discontinued in the speed-changing shaft by using a hydraulic clutch mechanism (forward/reverse speed-changing shaft **31** and auxiliary speed-changing shaft **33**), so it

is unnecessary to provide a separate clutch.

[0040] Incidentally, since slight dispersions occur in the operation of the hydraulic cylinder which actuates a component, such as a hydraulic device, and the main shifting shifter **56** due to slight dimensional errors in the hydraulic-related parts and the conditions, such as the hydraulic fluid temperature, the amount of time required for a shifting by the main speed-changing shaft **32** is not constant. Therefore, the timing for discontinuing the motive force in the speed-changing shaft by the hydraulic clutch mechanism does not match the timing of the shifting of the main speed-changing shaft **32**, so a shock is produced in the main speed-changing shaft **32**, or slippage of the clutch of the hydraulic clutch mechanism occurs.

[0041] By discontinuing the motive power during a shifting, rotation on the wheel side is decelerated by the resistance from the ground. Meanwhile, during a shifting in the high-speed range, the total deceleration ratio in front of/behind the traveling shifting device is smaller than before the change; hence, the shock is small even when the aforesaid timings shift slightly. Consequently, a shifting is performed by blocking the motive power in the forward/reverse speed-changing shaft **31**, which is the transmission upstream side of the main speed-changing shaft **32**. By contrast, since an error in the total deceleration ratio before/after the shifting increases during a shifting in the low-speed range and the shock is large even when the aforesaid timings shift slightly, the shifting is performed by blocking the motive power in the auxiliary speed-changing shaft **33**, which is the transmission upstream side of the main speed-changing

shaft **32**. Either discontinuing the motive power on the transmission upstream side or discontinuing the motive power on the transmission downstream side as such may be selected in accordance with the position of the shifting, and therefore, a smooth shifting is enabled in any position.

[0042] Shifting in the respective speed change parts **31, 32** and **33** is performed by electromagnetically controlled actuators, that is, the hydraulic clutches C_F, C_B, C_H, C_M, C_L and C_{LL} and the hydraulic cylinders **A** and **B** in a construction in which the respective actuators thereof are controlled by a CPU; hence, no deviation occurs in the timing for performing a shifting in the main speed-changing shaft **32** and the timing for turning on/off the hydraulic clutch of the forward/reverse speed-changing shaft **31** or the auxiliary speed-changing shaft **33** and a smooth and accurate shifting is always performed. /7

[0043] Since the main speed-changing shaft **32** is a structure in which a shifting gear for each step is arranged in a longitudinal series, by composing the main speed-changing shaft **32** with a synchromesh mechanism, the length in the longitudinal direction can be reduced greater than in a case in which it is composed of a hydraulic clutch mechanism. Moreover, as previously mentioned, the auxiliary speed-changing shaft **33** is short in the longitudinal and vertical directions; hence, the entire shifting device becomes compact. Furthermore, by employing a synchromesh mechanism whose structure is simpler and is cheaper to operate than a hydraulic clutch mechanism as the main speed-changing shaft **32**, a main speed-changing shaft may be realized at a lower cost.

[0044] Switching between the shifting devices is performed by the aforesaid gear change **17**, and as shown in Fig. 7, the gear change **17** is rotated longitudinally along a guide groove **18**, and each operating position for "ultra low," "rotary," "plow," "neutral," and "running" are provided in order from the back end to the front end of the rotation range thereof. "Ultra low" is a mode when work is performed in ultra low-gear, such as creeping work, "rotary" is a mode for rotary tilling work, "plow" is a mode for plow work, "neutral" is a mode where traveling is stopped, and "running" is a mode when traveling on a road. By selecting the work (or road travel) mode using the gear shift **17**, a multistep (4 to 6 steps) shiftable region suited to it is set. Furthermore, a manually operated acceleration button **17a** and a deceleration button **17b** are provided on the grip of the gear change **17**, and the speed is accelerated within the aforesaid shiftable region by using these shifting buttons **17a** and **17b**.

[0045] For example, the "rotary" shiftable region includes the 5^{th} to 10^{th} steps, and the initial selected "rotary" using the gear change **17** is the 7^{th} speed-changing position. Then, with the 7^{th} step as the starting point, the number of shifting steps increases one step at a time every time the accelerating button **17a** is pushed once, and the number of shifting steps decreases one step at a time every time the decelerating button **17b** is pushed once. The shiftable region and number of the steps of shifting from the starting point in the respective modes are as shown in Fig. 8.

[0046] [Advantages of the Invention]

The shifting device pertaining to the present invention has a construction in which the speed-changing shaft by using a hydraulic clutch

mechanism is disposed respectively on the transmission upstream and downstream sides of the speed-changing shaft using a synchromesh mechanism, and shifting is performed in the speed-changing shaft using a synchromesh mechanism by discontinuing the power transmission in the speed-changing shaft using a hydraulic clutch mechanism, so a smooth shifting was enabled without providing a separate clutch, and at the same time, a more compact and cheaper shifting device could be planned.

[Brief Description of the Drawings]

[Figure 1] Overall side view of a tractor.

[Figure 2] Drawing of transmission mechanism.

[Figure 3] Cross section of forward/reverse speed-changing shaft of travel shifting device and PTO forward/backup device.

[Figure 4] Cross section of main speed-changing shaft of traveling shifting device.

[Figure 5] Cross section of auxiliary speed-changing shaft of traveling shifting device.

[Figure 6] Drawing of hydraulic circuit for controlling shifting device.

[Figure 7] Perspective view of gear change.

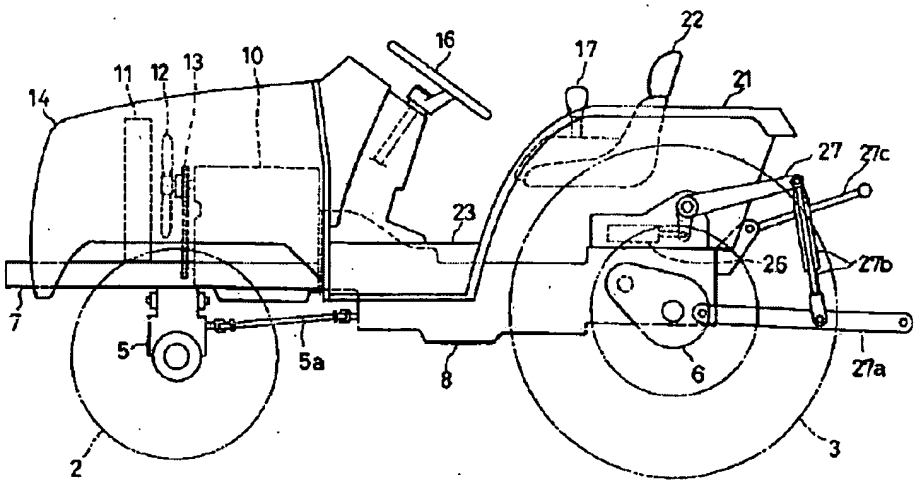
[Figure 8] Drawing representing combination of main shifting and auxiliary shifting in a shifting device, and running speed.

[Explanation of the Codes]

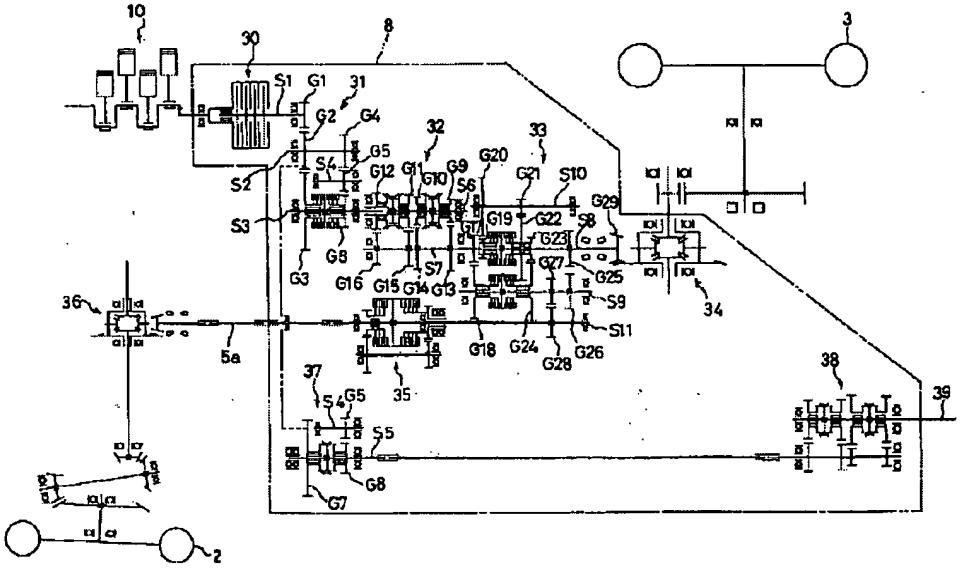
A, B: hydraulic cylinders (actuators using electromagnetic control), C_F, C_B, C_H, C_M, C_L and C_{LL}: hydraulic clutches (actuators using electromagnetic control); 1: tractor; 2: front wheel; 3: rear wheel; 8: automatic transmission

case; 17: gear change; 17a: accelerating button; 17b: decelerating button; 31: forward/reverse speed-changing shaft (speed-changing shaft using hydraulic clutch mechanism); 32: main speed-changing shaft (speed-changing shaft using synchromesh mechanism); 33: auxiliary speed-changing shaft (speed-changing shaft using hydraulic clutch mechanism)

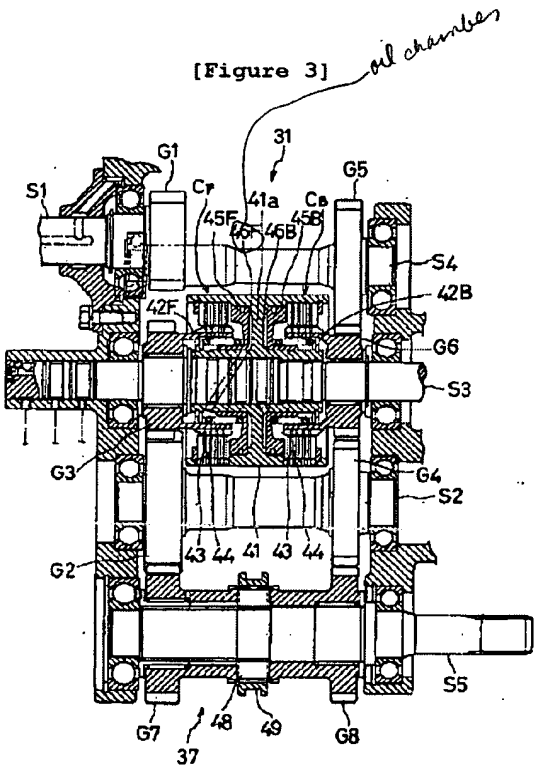
[Figure 1]



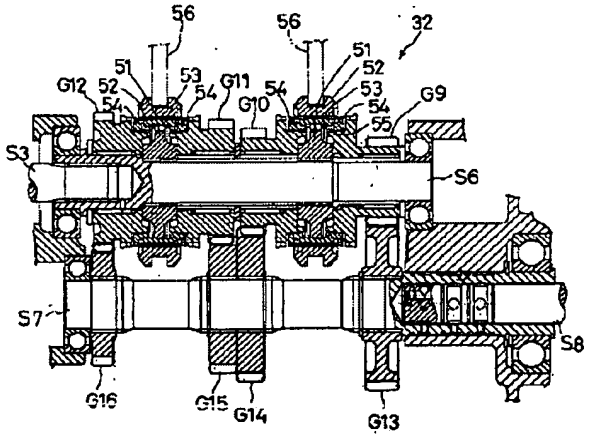
[Figure 2]



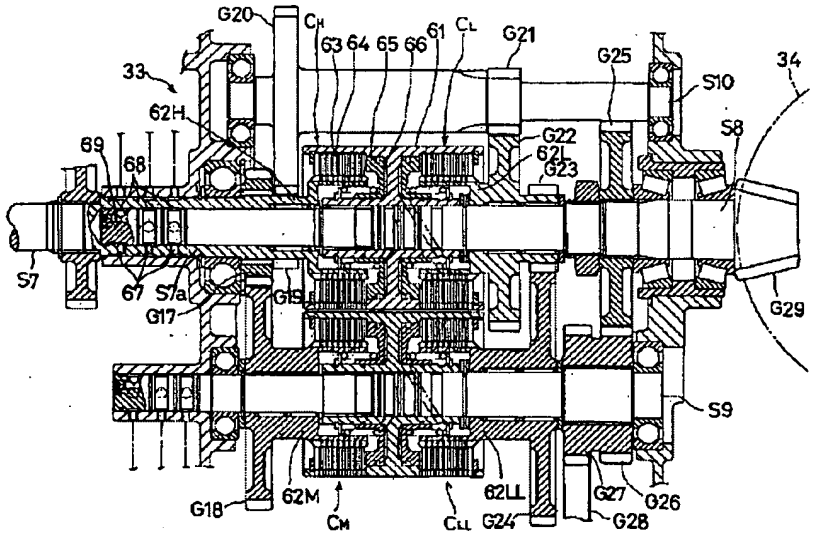
[Figure 3]



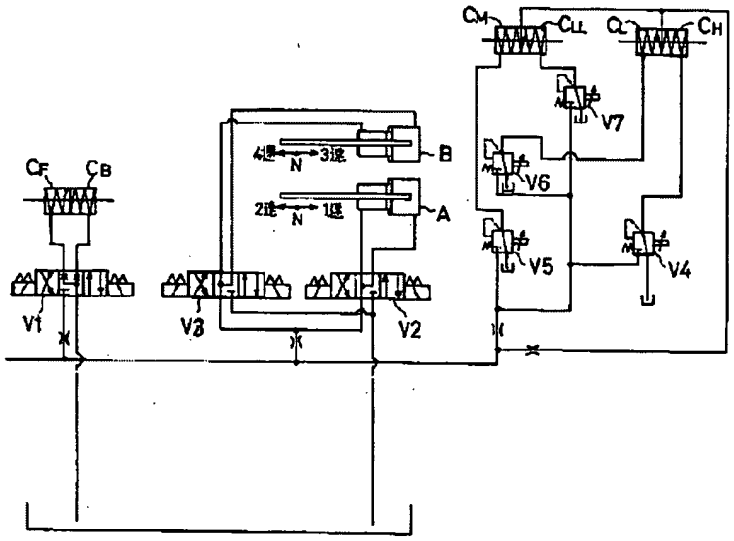
[Figure 4]



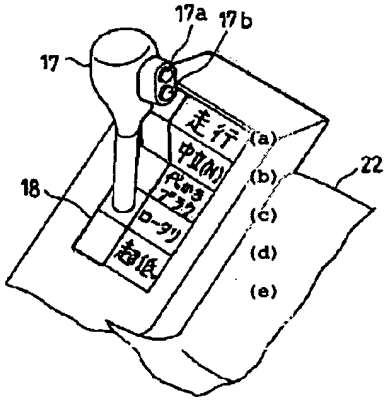
[Figure 5]



[Figure 6]



[Figure 7]



(a) running; (b) neutral(N); (c) plow; (d) rotary; (e) ultra low

[Figure 8]